

## Feasibility Study Appendix A - Ecological Risk Based Threshold (RBT) Derivation

Preliminary Remedial Goals (PRGs) are developed in the Feasibility Study (FS) based, in part, on the selection of ~~risk-risk~~-based thresholds (RBTs) for each medium of concern at the Portland Harbor Study Area. The ecological RBTs were selected separately for sediment, surface water, and ~~transition-transition-zone-zone~~-water (TZW) based on medium-specific Remedial Action Objectives (RAOs) described below. The ecological RBTs were selected from toxicity reference values (TRVs) developed for use in the Baseline Ecological Risk Assessment (BERA). TRVs were selected or derived for use in the BERA for each medium, receptor, and exposure pathway combination. The RBTs for each contaminant are identified below by abiotic medium and the derivation of each is described. Ecological RBTs for sediment are presented in Table A-1. Ecological RBTs for surface water and TZW are presented in Table A-2 and Table A-3, respectively.

Commented [GF1]: "Remediation" is used in Appendix A1 instead of "Remedial". Use consistent terminology.

### 1.0 Sediment RBTs

Sediment RBTs were selected to meet the objectives associated with **RAO 5**, which are to reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated sediments and to comply with identified applicable, relevant, and appropriate requirements (ARARs). This RAO applies to all ecological receptors found to have an unacceptable risk via direct sediment exposure in the BERA. The goals are to: 1) reduce potentially unacceptable risks to ecological receptors from contaminant concentrations in sediments through sediment remedies at the Site; 2) prevent unacceptable effects on the survival, growth, and reproduction of ecological receptors at the Site; and 3) comply with chemical-specific ARARs, if they have been identified for the Site.

Sediment RBTs also were selected to meet the objectives associated with **RAO 6**, which are to reduce to acceptable levels risks to ecological receptors from indirect exposures through ingestion of prey to contaminants of concern (COCs) in sediments via bioaccumulation pathways from sediment and/or surface water and to comply with ARARs, if they have been identified for the Site. This RAO applies to all ecological receptors found to have an unacceptable risk through ingestion of prey in the BERA. The goals are to: 1) reduce risks from contaminants through sediment remedies that protect ecological receptors from exposures to contaminants through consumption of fish and shellfish, benthic organisms, and other prey items exposed to contaminants via bioaccumulation and bioconcentration; 2) comply with chemical-specific ARARs if identified for the Site; and 3) protect the beneficial uses of the Willamette River at the Site. This RAO is expected to contribute to reduction of ~~prey-prey-ingestion-ingestion~~-related ecological risks through reduction in sediment chemical contributions to fish tissue. It is recognized that reduction of and elimination of these risks can only be achieved when conducted in conjunction with other Portland Harbor source control efforts conducted under other regulations and programs within the Willamette River watershed.

#### 1.1 Sediment RBTs for RAO 5

Nineteen contaminants or groups of contaminants in sediment are identified as sediment COCs. These include total polychlorinated biphenyls (PCBs), dioxins/furans (as 2,3,7,8-TCDD TEQs), ~~3-three~~ categories of polycyclic aromatic hydrocarbons (PAHs) (total, low molecular weight (LPAH), high molecular weight (HPAH)), total petroleum hydrocarbons (TPH), ~~5-five~~ pesticides, ~~6-six~~ metals, bis(2-ethylhexyl)phthalate (BEHP), and tributyltin (TBT). Sediment RBTs (micrograms per kilogram (ug/kg) or milligrams per kilogram

(mg/kg dry weight (dw) sediment) were selected or calculated from candidate TRVs for all of these sediment COCs except dioxins/furans and mercury. Sediment RBTs for the remaining 17 contaminants other than dioxins/furans and mercury were selected from 3-three TRV categories. These include the following:

- Linear Regression Model (LRM) TRV for protection of benthic macroinvertebrates (BMI)
  - Hydrocarbons: Total HPAHs and TPH (C<sub>10</sub> to C<sub>12</sub> aliphatic/aromatic hydrocarbons)
  - Butyltins: Tributyltin
- Probable Effects Concentration (consensus-based PEC; MacDonald et al. 2000)
  - Hydrocarbons: Total PAHs and Total LPAHs
  - Pesticides: aldrin, dieldrin, total DDX, gamma-HCH (Lindane), and total chlordanes
  - Metals: cadmium, chromium, copper, lead, and zinc
- Tissue Residue-based Effects Concentration
  - Total PCBs and BEHP: Smallmouth bass, protection of piscivorous fish

Linear Regression Model relates the results of sediment toxicity testing to contaminant concentrations in Study Area sediments. Individual LRMs (Field et al. 1999; Field et al. 2002; EPA 2005) were developed for chemicals of interest. For each chemical, model developers fit 72 unique models from which the best individual model was selected. For each chemical, the 72 individual models were developed using the following:

- Two pooled species endpoints (i.e., *Hyalella azteca* and *Chironomus dilutus*)
- Three toxicity levels (i.e., L1, L2, or L3)
- Four sediment chemistry normalizations (i.e., dry weight, organic carbon (OC)-normalized, fines-adjusted dry weight concentrations, and fines-adjusted OC-normalized concentrations).

Sediment Sediment toxicity toxicity-test-test-based TRVs are expressed as the minimum percent survival or the minimum percent biomass reduction relative to survival or biomass in the laboratory negative control sediment response. For a station to fail, these TRVs for survival or biomass must also be statistically significantly reduced from the laboratory negative control sediment survival or biomass. Benthic toxicity TRVs are the lower end (i.e. smallest adverse effect) of the Level 2 (moderate toxicity) effect level. The BERA classified each individual station as falling within one of four levels of toxicity for each toxicity test: Level 0 (reference areas), Level 1 (low toxicity), Level 2 (moderate toxicity) or Level 3 (severe toxicity).

LRM-based TRVs derived from sediment toxicity testing with *H. azteca* and *C. dilutus* include the following:

- TBT TRV (3.1 mg/kg dw sediment) is the L2 SQV from the LRM.
- TPH (C-10 to C-12 aliphatic/aromatic) TRV (11 mg/kg dw sediment) is the mean of the L2 and L3 SQV from the LRM
- HPAH TRV (150 mg/kg dw sediment) is the L2 SQV from the LRM

Probable Effects Concentrations (PECs) (MacDonald et al. 2000) are consensus-based contaminant sediment concentrations above which adverse effects on sediment-dwelling organisms are likely to occur. The PECs were derived as geometric means of sediment quality guidelines (SQGs; including effects range median (ERMs) and probable effect levels (PELs)) in the literature with similar narrative intent.

Tissue-residue based Effects Concentration TRVs for smallmouth bass are based on sediment contaminant concentrations (ug/kg dw) calculated to maintain whole body fish contaminant concentrations below those linked to ecologically significant adverse effects for piscivorous fish (represented by smallmouth bass).

**Commented [BLJ2]:** Explain why RBTs were not calculated for dioxins/furans and mercury

**Commented [TG3]:** PEC for Hg = 1.1 as shown on TRV table, but not shown as selected for RBT for RAO 5. Not sure why 1.1 is not the Hg sediment RBT for RAO 5. BURT, CAN YOU CONFIRM NON-SELECTION OF HG TRV AS RBT?

**Commented [BLJ4]:** Phrasing is potentially ambiguous – not clear from which of the two groups in prior sentence these are “remaining” – say instead “17 contaminants other than dioxins/furans and mercury”

**Commented [BLJ5]:** It would be helpful to explain why a particular method was used for particular analytes.

**Commented [BLJ6]:** Indicate the criteria for selection of “the best model.”

**Commented [BLJ7]:** That would seem to be 2 x 3 x 4 = 24 models. How do you arrive at 72?

**Commented [BLJ8]:** This needs to be written out in text rather than in this shorthand.

**Commented [TG9]:** L2 = 10 and L3 = 12, and TRV of 11 is assumed to be the mean of the two – BURT, CAN YOU CONFIRM THIS ASSUMPTION?

- For PCBs, the smallmouth bass tissue-residue based TRV of 64 ug/kg (dw, sediment) is based on.....
- For BEHP, the smallmouth bass tissue-residue based TRV of 135 ug/kg (dw, sediment) is based on.....

**Commented [JMK10]:** Burt, can you provide the rationale for development/selection of these values? TG = Assume use of BSAF and fish residue-based threshold (0.93 mg/kg ww), but cannot confirm. BSAF appears to be ~14.5

### 1.2 Sediment RBTs for RAO 6

RBTs for RAO 6 are identified for ~~2-two~~ sediment COCs: total PCBs and dioxins/furans (as 2,3,7,8-TCDD TEQs). For RAO 6, the sediment RBT for total PCBs is based on the:

**Commented [BLJ11]:** Indicate why other 17 contaminants are not considered here.

- TRV resulting from the dietary assessment for mink, representing ~~aquatic-aquatic~~-dependent carnivorous mammals.

**Commented [BLJ12]:** Include a short explanation as to why mink can be used to represent all such species.

The sediment RBT for aquatic dependent carnivorous mammals (represented by mink) exposed to PCBs via ingestion of prey (31 ug/kg dw sediment) is based on total PCB concentrations in an assumed mink diet of fish (smallmouth bass, carp, and sculpin), and crayfish collected from the Study Area. The RBT is calculated using food web modeling (with specific inputs and assumptions) from the dose-based LOAEL presented in Restum et al. (1998) of 0.037 mg/kg body weight (bw)-day.

**Commented [TG13]:** Use of FWM to back calculate sediment value of 31 ug/kg from LOAEL dose of 0.037 mg/kg-d needs to be confirmed BY BURT.

The sediment RBT for dioxin/furan 2,3,7,8-TCDD TEQs is based on the:

- TRV resulting from the bird egg assessment for ~~population-level effects on~~ bald eagle, ~~population-level effects~~, representing piscivorous birds.

The selected bird egg TRV of 0.0034 ug/kg (dw, sediment) for 2,3,7,8-TCDD TEQ (or 2,3,4,7,8-PeCDF, since the avian TEF for both chemicals are the same according to van den Berg et al. 1998) is based on the egg NOAEL (2.3 ng/kg wet weight (ww) egg) from an osprey productivity study in the Willamette River ~~OR ON~~ the LOAEL (31.98 nanograms per kilogram (ng/kg) ww egg) from a field study with bald eagle.

**Commented [JMK14]:** Burt, can you please confirm which is accurate? TEXT IS UNCLEAR WHICH WAS THE FINAL BASIS FOR THE TRV (NOAEL OR LOAEL)

## 2.0 Surface Water RBTs

Surface water RBTs were selected to meet the objectives associated with RAO 6, which is described above.

Surface water RBTs also were selected to meet the objectives associated with RAO 7, which are to reduce risks from COCs in surface water at the Site to acceptable exposure levels that are protective of ecological receptors based on the ingestion of and direct contact with surface water and to comply with identified ARARs. This RAO applies to all ecological receptors found to have an unacceptable risk through exposure to surface water. The goals are to: 1) reduce potentially unacceptable risk from contaminant concentrations in surface water to the extent practicable, as discussed above, through sediment remedies that prevent unacceptable effects on survival, growth, and reproduction of ecological receptors; 2) comply with chemical-specific ARARs, if identified; and 3) protect the beneficial uses of the Willamette River.

### 2.1 Surface Water RBTs for RAO 6

Thirty-one COCs are identified for surface water, and the ~~BERA-BERA~~-derived TRVs for 15 of these COCs. None of these TRVs were selected as surface water RBTs for RAO 6.

**Commented [BLJ15]:** This is non-grammatical—a verb is missing.

**Commented [BLJ16]:** The reasons for this need to be explained.

### 2.2 Surface Water RBTs for RAO 7

The surface water TRVs derived for 15 of the 31 surface water COCs were selected as surface water RBTs for RAO 7. The sources of these TRVs serving as surface water RBTs for RAO 7 are presented below. In all cases these TRVs are based on chronic criteria or chronic values intended to protect most of the nation's aquatic life most of the time (i.e., protection of 95% of aquatic species, with allowable exceedance of these values not to exceed once every three years). Aquatic life is defined for this purpose as aquatic plants (including algae), water column and benthic invertebrates, fish, and larval amphibians).

**Commented [BLJ17]:** Indicate the basis for the selection (and exclusion of other COCs).

**Commented [BLJ18]:** Indicate the provenance of this particular criterion.

#### The 15 COCs selected for Surface Water RBTs are:

- Chronic National Recommended Water Quality Criteria (NRWQC; EPA 2006a), dissolved, adjusted to hardness of 25 mg/L CaCO<sub>3</sub>:
  - Cadmium
  - Copper
  - Lead
  - Zinc
- Chronic NRWQC (EPA 2006a)
  - Total DDX
  - Total PCBs
  - Cyanide
- Tier II Secondary Chronic Value (Suter and Tsao 1996)
  - Total LPAHs (naphthalene)
  - Total HPAHs (benzo(a)pyrene)
  - 1,2-Dichlorobenzene
  - Ethylbenzene
  - BEHP
  - Chlorobenzene
  - Chloroform
  - Trichloroethylene (TCE)

### **3.0 Transition-Transition-Zone-Zone-Water (TZW) RBTs**

TZW RBTs were selected to meet the objectives associated with **RAO 8**, which are to reduce to acceptable levels the risks to ecological receptors resulting from the ingestion of and direct contact with contaminated groundwater and indirect exposures through ingestion of prey via bioaccumulation pathways from groundwater, and to comply with ARARs, if identified for the Site. This RAO applies to all ecological receptors found to have an unacceptable risk via exposure to contaminated groundwater plumes discharging to the Willamette River and through ingestion of prey with the understanding that groundwater plumes will be controlled to achieve ARARs and risk-based remediation goals through upland source control actions. The goals are to: 1) reduce potentially unacceptable risks to ecological receptors from contaminant concentrations in groundwater through sediment remedies at the Site to the extent feasible; 2) prevent unacceptable effects on the survival, growth, and reproduction of ecological receptors at the Site; and 3) comply with chemical-specific ARARs, if identified for the Site. However, sediment remedies cannot have any direct impact on upland known sources, which remain the primary mechanism for reducing risks from groundwater plumes to in-water receptors. Therefore, this RAO would only apply to groundwater plumes downgradient of the upland source control measure.

#### **3.1 Transition Zone Water (TZW) RBTs for RAO 8**

Thirty-eight COCs are identified for TZW. The TZW TRVs derived for 22 of the 38 TZW COCs were selected as TZW RBTs for RAO 8. No TZW TRVs were derived for the other 16 COCs. The sources of these TRVs serving

**Commented [BLJ19]:** Indicate why these 22 were selected and the others excluded.

as TZW RBTs for RAO 8 are presented below. Although TZW exposures are focused on benthic invertebrates, the sources listed below, except for the one associated with m- and p-xylene, include chronic criteria or chronic values intended to protect most of the nation's aquatic life most of the time. These TRVs, therefore, are applicable but are not limited to protection of benthic invertebrates.

- Chronic NRWQC (EPA 2006a), dissolved, adjusted to hardness of 25 mg/L CaCO<sub>3</sub>:
  - Lead
  - Zinc
- Chronic NRWQC (EPA 2006a)
  - Total DDX
  - Manganese
  - Cyanide
- Tier II Secondary Chronic Value (Suter and Tsao 1996)
  - Total LPAHs (naphthalene)
  - Total HPAHs (benzo(a)pyrene)
  - 1,2-Dichlorobenzene
  - Ethylbenzene
  - Chlorobenzene
  - Chloroform
  - TCE
  - Vanadium
  - Benzene
  - 1,1-Dichloroethene
  - Cis-1,2-Dichloroethene
  - Toluene
  - o-Xylene
  - Total Xylene
- Memorandum from D. Mount to ERAF tri-chairs. September 2006: Error in prior calculation of GLI Tier II SCV for m-xylene. National Health and Environmental Effects Research Laboratory, US Environmental Protection Agency, Duluth, MN (EPA 2006b)
  - m- and p-Xylene
- TRVs developed using methods for derivation of NRWQC
  - Perchlorate
- CONCAWE (Conservation of Clean Air and Water in Europe). 1996. (Specific TRV calculations and rationale presented in Appendix A).
  - TPH (C<sub>10</sub> to C<sub>12</sub> aliphatic/aromatic)

#### 4.0 References

Conservation of Clean Air and Water in Europe (CONCAWE). 1996. Environmental risk assessment of petroleum substances: the hydrocarbon block method. Report no. 96/52.

EPA. 2005. Predicting toxicity to amphipods from sediment chemistry. EPA/600/R-04/030. National Center for Environmental Assessment, US Environmental Protection Agency, Washington, DC.

EPA. 2006a. National recommended water quality criteria (4304T). November 2002. US Environmental Protection Agency, Washington, DC.

EPA. 2006b. Memorandum dated September 13, 2006 from D. Mount to ERAF tri-chairs (B. Pluta, M. Sprenger, V. Madden): Error in prior calculation of GLI Tier II SCV for m-xylene. National Health and Environmental Effects Research Laboratory, US Environmental Protection Agency, Duluth, MN.

Field LJ, MacDonald DD, Norton SB, Severn CG, Ingersoll CG. 1999. Evaluating sediment chemistry and toxicity data using logistic regression modeling. *Environ Toxicol Chem* 18:1311-1322.

Field LJ, MacDonald DD, Norton SB, Ingersoll CG, Severn CG, Smorong D, Lindskoog R. 2002. Predicting amphipod toxicity from sediment chemistry using logistic regression models. *Environ Toxicol Chem* 21(9):1993-2005.

MacDonald DD, Ingersoll CG, Berger TA. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch Environ Contam Toxicol* 39(5):20-31.

Restum JC, Bursian SJ, Giesy JP, Render JA, Helferich WG, Shipp EB, Verbrugge DA. 1998. Multigenerational study of the effects of consumption of PCB-contaminated carp from Saginaw Bay, Lake Huron, on mink. 1. Effects on mink reproduction, kit growth and survival, and selected biological parameters. *J Toxicol Environ Health* 54(A):343-375.

Suter GW, Tsao CL. 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. Prepared for U.S. Department of Energy Office of Environmental Management. Risk Assessment Program, Health Sciences Research Division.

Van den Berg M, Birnbaum L, Bosveld ATC, Brunström B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy S, Kubiak T, Larsen JC, van Leeuwen FXR, Dijen Liem AK, Nolt C, Peterson RE, Poellinger L, Safe S, Schrenk D, Tillitt D, Tysklind M, Younes M, Waern F, Zacharewski T. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. *Environ Health Perspect* 106(12):775-792.